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PROGRESS REPORT
TEST OF INSECTICIDES
TO CONTROL THE WHITE PIR NEEDLE MINER

BRYCE CANYON NATIONAL PARK
UTAH

By

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Entomologist

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Ogden, Utah
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The white fir stands, Abies concolor (Gord. & Glend.) Hoopes, in and around Bryce Canyon National Park are currently heavily infested with the white fir needle miner, Epinotia meritana Hein. The present epidemic infestation has been in progress since about 1950 and has increased in severity each year. Several attempts to control this insect by ground and aerial application of insecticides, principally DDT, have met with failure or at best produced only a partial and temporary reduction of the needle miner population. By 1956 a high proportion of the fir trees had lost 90% or more of their foliage.

In 1955 an exploratory study was undertaken to screen various insecticides and formulations to determine their toxicity to the needle miner. Since the fir needle miner spends its larval and pupal stages within the needle of the white fir, an insecticide must have the ability to penetrate the outer shell of the mined needles, either by absorption or through the entrance holes made by the feeding larvae in order to be effective. In 1956 selected insecticides that showed some promise were tested more thoroughly. This study was cooperative between the Division of Forest Insect Research and the National Park Service.

MATERIALS

The technique devised to test the effectiveness of the various insecticidal formulations required an apparatus that could spray a uniform deposit on the test branches, a method of recovering insects affected by initial "knock down", and a system of counting all insects that remained within the sprayed branches after maximum mortality had occurred.

The spray apparatus used was a small pressure tank of the type used in Service Stations to clean auto windshields. (Photo 1). Air pressure of 80 lbs. per sq. in. was obtained by using a tire pump, and checked by

an ordinary tire pressure gauge. This sprayer had a capacity of 12 oz. and produced a uniform spray pattern and droplet size that resulted in a rapid even surface coverage. The sprayer was thoroughly cleaned between applications in xylene to remove all danger of contamination.

Cloth trays approximately one square yard in size were set up to catch and retain all "knock down" that occurred from branch tips suspended on wires above the trays, (Photo 2). All insecticide formulations were mixed in the field at the time of the test and included Malathion, DDT, Dieldrin, and Julius Hyman 269. Concentrations and mixtures used are listed in Table 1.

METHODS

A quantity of randomly selected infested branch tips about 6 inches in length were collected for the test not more than ten minutes before the application of the insecticide. Five tips were drawn from the collection, again at random, and sprayed with a formulation of insecticide. An attempt was made to spray each branch tip at the approximate rate of 1 gallon per acre. Drop size and dosages were determined from spray deposit cards previously treated with an oil soluble dye by comparison with standards representing various dosage rates and drop sizes. Immediately after spraying, the tips were suspended on a wire over a cloth tray. The amount of direct sunlight and shading available differed between trays. In order to discount any differences that might exist, lots were drawn to assign the sprayed branch tips to cloth trays.

All "knock down" was recorded at intervals of one hour, two hours, twenty-four hours, and forty-eight hours after application of the insecticide and all insects that dropped to the trays were counted as dead. Forty-eight hours after the spray was applied all needle miners remaining on sprayed branch tips were removed from the mined needles and the mortality recorded.

Using infested branch tips as the test units introduced an independent variable, the variation of the needle miner population within the branch tips. In addition during the final mortality examination, some of the needles from sprayed branch tips were blown away. Wherever this occurred that sample was discarded. In order to remove the effects of these independent variables a covariance analysis was run, and the mortalities weighted according to the adjusted mean number of dead insects.

RESULTS

The results of the analysis of the mortalities produced by the various treatments are summarized. (Table 2).

All treatments with Malathion produced mortalities in excess of 90% but no concentration produced a mortality significantly different from one another. All were, however, significantly different from the check at the 5% level.

One formulation containing an equivalent of one pound of DDT per gallon with the addition of about 1/8% by volume of technical grade ethylene dibromide killed 95% of the test larvae. None of the other treatments of DDT solutions killed more than 74% of the larvae.

In the branch tips sprayed with formulations of dieldrin, mortalities were so low that they did not differ significantly from the check.

Results of the test with Julius Hymen 269 show that a 1 pound concentration gave much better mortality (92%) than a 1.6 pound concentration (77%). This difference might be due to differences in the rate of crystallization of the two concentrations.

Unsprayed branch tips for the check were handled in the same manner as all sprayed samples. The recorded 25% mortality in the checks was made up primarily of dead larvae within needles.

DISCUSSION

In all tests conducted, Malathion produced mortalities suficiently high to be considered effective. No significant differences were found between the various dosages of Malathion tested. Most of the needle miner larvae killed by the Malathion sprays died within needles, with only 9.3% of dead larvae being recorded in the trays as "knock down".

Only one formulation of DDT produced a larval mortality in excess of 90% and that formula contained about 1/8% by volume of technical grade ethylene dibromide. Approximately 40% of the needle miner larvae affected by DDT formulations left the needles and dropped to cloth trays by threads, (Table 3). Mortality occurring as "knock down" can be a serious nuisance in a highly used National Park.

The results of these tests indicate that it may be practical to control the larval stage of the needle miner by the application of an insecticide. However, it must be determined if any of the more effective insecticides applied under the experimental conditions described,

will produce the high rate of mortality (90% or more) desirable for a control measure under conditions normally experienced in field applications. If possible two areas, each containing about 1500 acres should be sprayed by airplane in 1957 to test control possibilities. One area should be sprayed with an oil solution containing 1 pound of Malathion per gallon, and the other with an oil solution containing 2 pounds of Malathion per gallon, both at the rate of 1 gallon per acre.

INSECTICIDE FORMULATIONS TESTED

TABLE 1.

Insecticide	Formula No.	Equivalent per gal. in lbs.	Dilution for 100 Milliliter Conc.	Fuel Oil
DDT		(Concentrate 2 lbs. per gal.)		
	1	1	50 ml.	50 ml.
	2	1.5	75 ml.	25 ml.
	3	2.0	100 ml.	-
Dieldrin		(Concentrate 1.5 lbs. per gal.)		
	4	.75	50 ml.	50 ml.
	5	1.5	100 ml.	-
Malathion		(Concentrate 5 lbs. per gal.)		
	6	1.	20 ml.	80 ml.
	7	1.5	30 ml.	70 ml.
	8	2	40 ml.	60 ml.
Julius Hyman 269		(Concentrate 1.6 lbs. per gal.)		
	9	.8	50 ml.	50 ml.
	10	1.6	100 ml.	
DDT + EDB		(Concentrate 2 lbs. per gal.)		
	11	1 lb. - 1/8% EDB Conc.	50 ml.	50 ml.
Malathion + EDB		(Concentrate 5 lbs. per gal.)		
	12	1 lb. - 1/8% EDB Conc.	20 ml.	80 ml.
	13	2 lbs. - 1/8% EDB Conc.	40 ml.	60 ml.

TABLE 2

RESULTS OF INSECTICIDE TESTS

FIR NEEDLE MINER — BRYCE CANYON N.P. 1956

NO.	TREATMENTS FORMULA	ADJUSTED MEAN NO. DEAD INSECTS	PERCENT DEAD
13	MALATHION 2 LBS. + E.D.B.		99
11	D.D.T. 1 LBS. + E.D.B.		95
6	MALATHION 1 LB		97
12	MALATHION 1 LB. + E.D.B		100
8	MALATHION 2 L.BS.		94
7	MALATHION 1.5 LBS.		96
9	J. H. 269 .8 LB.		92
2	D.D.T. 1.5 LBS.		80
1	D.D.T. 1 LB.		84
3	D.D.T. 2 LBS.		77
10	J.H. 269 1.6 LBS.		77
14	CHECK		25
5	DIELDRIN 1.5 LBS.		18
4	DIELDRIN 1 LB.		32

COMPARISONS

	13	11	6	12	8	7	9	2	1	3	10	14	5	4
MALATHION 2 LBS. + E.D.B. 13	–	N	N	N	N	N	N	.05	.05	.05	.01	.01	.01	.01
D.D.T. 1 LB. + E.D.B. 11	N	–	N	N	N	N	N	N	N	N	.05	.01	.01	.01
MALATHION 1 LB. 6	N	N	–	N	N	N	N	N	N	N	N	.05	.01	.01
MALATHION 1 LB. + E.D.B. 12	N	N	N	–	N	N	N	N	N	N	N	.05	.01	.01
MALATHION 2 LBS. 8	N	N	N	N	–	N	N	N	N	N	N	.05	.01	.01
MALATHION 1.5 LBS. 7	N	N	N	N	N	–	N	N	N	N	N	.05	.01	.01
J.H. 269 .8 LB. 9	N	N	N	N	N	N	–	N	N	N	N	.05	.01	.01
D.D.T. 1.5 LBS 2	.05	N	N	N	N	N	N	–	N	N	N	N	.05	.01
D.D.T. 1 LB. 1	.05	N	N	N	N	N	N	N	–	N	N	N	.05	.01
D.D.T. 2 LBS. 3	.05	N	N	N	N	N	N	N	N	–	N	N	N	.01
J.H. 269 1.6 LBS. 10	.01	.05	N	N	N	N	N	N	N	N	–	N	N	.05
CHECK 14	.01	.01	.05	.05	.05	.05	.05	N	N	N	N	–	N	N
DIELDRIN 1.5 LBS. 5	.01	.01	.01	.01	.01	.01	.01	.01	.05	.05	N	N	N	–	N
DIELDRIN 1 LB. 4	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.05	N	N	–

M.S.D. .05 = 4.92275

M.S.D. .01 = 6.60570

N. = NOT SIGNIFICANT

.05 = SIGNIFICANT .05 LEVEL

.01 = SIGNIFICANT .01 LEVEL

TABLE 3. NEEDLE MINER LARVAL MORTALITY OCCURRING AFTER APPLICATION OF VARIOUS CONCENTRATIONS OF DDT AND MALATHION

Concentration*	No. dead on trays	No. dead within needles	Percent of total dead recovered on trays
DDT 1 lb.	15	38	39.5
DDT 1½ lb.	17	47	36.2
DDT 2 lb.	21	49	42.9
Total	53	134	39.5
Malathion 1 lb.	7	44	15.9
1½ lb.	4	28	12.3
2 lb.	2	68	2.9
Total	13	140	9.3

* lbs. per gallon

Photo 1. Self contained air pressure sprayer used to spray fir needle miner infested branches for insecticide tests.

Photo 2. Cloth tray used to catch "knock down" from sprayed branches suspended from wires.

Photo 3. Field "set up" used to test effects of insecticides on fir needle miner.

A P P E N D I X

Computation

Insecticide Tests Fir needle miner Bryce Canyon N.P. 1956

Treatments X = no. insects counted Y = no. dead insects

Replications	1 X	1 Y	2 X	2 Y	3 X	3 Y	4 X	4 Y	5 X	5 Y	6 X	6 Y	7 X	7 Y	8 X	8 Y	9 X	9 Y	10 X	10 Y	11 X	11 Y	12 X	12 Y	13 X	13 Y	14 X	14 Y
A	18	10	16	15	29	25	21	12	23	3	9	9	6	6	11	11	8	8	9	8							8	0
B	22	16	30	22	13	11	17	3	4	1	20	20	14	14	58	54	12	12	19	11							8	3
C	12	12			22	13	15	2	7	2	17	15	7	6	3	3	12	12									9	1
D	95	85			34	26					8	8					50	44	42	28	28	27	10	10	48	48	5	4
E	13	11			21	17					5	5					33	30	40	38	33	31	2	2	32	31	14	3
total	160	134	46	37	119	92	53	17	34	6	59	57	27	26	72	68	115	106	110	85	61	58	12	12	80	79	44	11
%Dead		84		80		77		32		18		97		96		94		92		77		95		100		99		25

r Correlation Coef:

$r_{totals} = \sqrt{\frac{12,810.0204^2}{(13,975.0612)(12,939.6735)}} = .96610$

$r_{bet.} = \sqrt{\frac{5,813.3061^2}{(6,420.4898)(5,897.3878}} = .94473$

$r_{with} = \sqrt{\frac{6996.7143^2}{(7,554.5714)(6,840.2857}} = .97331$

b regression Coef.:

$b = \frac{6,996.7143}{7,554.5714} = .92615$

Covariance Analysis

Variability due to.	D.F.	Squares and Products X	XY	Y	r	D.F.	adjusted sums of squares Sums of sqs.	Mean of sqs.	obs F
Totals	49	13,975.0612	12,810.0204	12,737.6735	.96	48	995.5328		
Between treatments	13	6,420.4898	5,813.3061	5,897.3878	.94	13	635.2985	48.8691	4.75
Within treatments	36	7,554.5714	6,996.7143	6,840.2857	.97	35	360.2343	10.2924	

Variance Analysis

Req F .05	Req F .01	X Mean of Sqs.	obs. F	Req F .05	Req F .01	Y Mean of Sqs.	obs F.
2.00	2.72	493.8938	2.35	2.02	2.71	453.6452	2.39
		209.8492				190.0079	

Totals $\Sigma X = 992$ $\bar{x} = 20.24$ $\Sigma XY = 28,763$ $N = 49$ $N_t = 3.5$ $\Sigma Y = 788$ $\bar{y} = 16.08$

$\Sigma X^2 = 34,058$ $\Sigma Y^2 = 25,410$

Correction term $\frac{(\Sigma X)^2}{N} = 20,082.9388$ $\frac{(\Sigma X)(\Sigma Y)}{N} = 15,952.9796$ $\frac{(\Sigma Y)^2}{N} = 12,672.3265$

$\Sigma X^2 - \frac{(\Sigma X)^2}{N} = 13,975.0612$ $\Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{N} = 12,810.0204$ $\Sigma Y^2 - \frac{(\Sigma Y)^2}{N} = 12,737.6735$

$\frac{\Sigma tx^2}{Nt} = 26,503.4286$ $\frac{(\Sigma tx)(\Sigma ty)}{Nt} = 21,766.2857$ $\frac{\Sigma ty^2}{Nt} = 18,569.7143$

Between $\frac{\Sigma ty^2}{Nt} - \frac{(\Sigma y)^2}{N} = 6,420.4898$ $\frac{(\Sigma tx)(\Sigma ty)}{Nt} - \frac{(\Sigma x)(\Sigma y)}{N} = 5,813.3061$ $\frac{\Sigma ty^2}{Nt} - \frac{(\Sigma y)^2}{N} = 5,897.3878$

with in $\Sigma x^2 - \frac{\Sigma tx^2}{Nt} = 7,554.5714$ $\Sigma y^2 - \frac{\Sigma ty^2}{Nt} = 6,840.2857$

Adjusted Sums of Squares:

EE totals $= 12,737.6735 - \frac{12,810.0204^2}{13,975.0612} = 995.5328$

EE bet. = EE totals − EE with = 635.2985

EE with. $= 6,840.2857 - \frac{6,996.7143^2}{7,554.5714} = 360.2343$

M.S.D. (min. dif required for significance for adjusted means)
(t value for 35 DF)

at .05 level $= 2.030\sqrt{10.2924(2) \div 3.5} = 4.922275$

at .01 level $= 2.724\sqrt{10.2924(2) \div 3.5} = 6.60570$

Computation
Cont.

Treat. No.	X mean no insects	deviation from exp. mean 20.24	Product deviation "b" .92615	Y mean no dead insects	Original Rank	Adjusted mean no. of dead insects	Adj. Rank	% Dead
1	32.00	+ 11.76	10.8915	26.80	8	26.80 - 10.8915 = 15.9085	9	84
2	23.00	+ 2.76	2.5562	18.50	9	15.9438	8	80
3	23.80	+ 3.56	3.2971	18.40	10	15.1029	10	77
4	17.67	- 2.57	-2.3802	5.67	12	8.0502	14	32
5	11.33	- 8.91	-8.2520	2.00	14	10.2520	13	18
6	11.80	- 8.44	-7.8167	11.40	3	19.2167	3	97
7	9.00	-1124	-10.4020	8.67	4	19.0720	6	96
8	24.00	+ 3.76	3.4823	22.67	6	19.1877	5	94
9	23.00	+ 2.76	2.5562	21.20	7	18.6438	7	92
10	27.50	+ 7.26	6.7238	21.25	11	14.5262	11	77
11	30.50	+10.26	9.5023	29.00	5	19.4977	2	95
12	6.00	- 14.24	-13.1884	6.00	1	19.1884	4	100
13	40.00	+ 19.76	18.3007	39.50	2	21.1993	1	99
14	8.80	- 11.44	10.5952	2.20	13	12.7952	12	25